REMARKS

Claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 remain pending for further prosecution in the present application. Applicants submit arguments for overcoming the rejection based on the prior art of record and respectfully submit that the present application is in condition for allowance.

Claim Rejections – §103(a)

> *In the FINAL Office Action, claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 are rejected under §103(a) as being obvious over JP 06-177128 A in view of U.S. Patent No. 6,451,135 B1 issued to Takahashi et al.*

Independent claims 3, 7 and 28 of the present application are each directed to a copper alloy sputtering target. The present inventors developed the copper alloy sputtering target to form thin copper alloy films (i.e., having a thickness of 500Å (0.05μm)) for the purpose of providing seed layers (also referred to as "interconnection layers") of a semiconductor device. By definition, a seed layer forms a base layer on which copper can be electrolytically plated. The seed layer according to the present invention provides improved wettability (coagulation resistance) to an underlying Ta/TaN diffusion barrier layer, possesses a requisite amount of conductivity enabling electrolytic copper plating of copper wiring material, possesses electromigration resistance and oxidation resistance, and inhibits the occurrence of voids, hillocks and disconnections that often occur during electrolytic copper plating. Further, the seed layer according to the present invention must be very thin, i.e. approximately 500Å (0.05μm), as indicated, for instance, on the last two lines of page 9 of the present application, as filed.

It should be understood, that it is an **extremely formidable challenge** to form a uniform film of a thickness of only about 500Å (0.05μm) that is able to accomplish all of the above. If

there is any problem in the uniformity of the film, voids, hillocks and disconnections will occur during the electrolytic copper plating. The thickness of the required seed layer is less than 1/10 of the thickness of a film used as the wiring (such as disclosed, for instance, by JP '128). Thus, producing a copper alloy sputtering target that is able to form the above seed layer is also an extremely formable challenge.

Among other limitations, the copper alloy sputtering target of the claims of the present application is required to be made of a copper alloy containing 0.2 to 5 wt% of aluminum (Al) (see claims 3, 7 and 28) and to have a resistivity of at least 2.2 $\mu\Omega$ cm (see claims 3 and 28).

In the Office Action dated January 6, 2009, JP '128 is cited as the primary reference in the above referenced obviousness rejection because JP '128 discloses a copper alloy sputtering target containing 0.02 to 20 atomic percent of aluminum. EP 0601509 A1 corresponds to JP '128 and provides a full English language translation.

The copper alloy sputtering target of JP '128 is specifically designed to form a thin film of a thickness of about 0.7μm (7,000Å). This thin film itself provides copper wiring of a semiconductor device. (See Table 1 of EP 0601509 A1 which provides a disclosure of this thickness). Thus, unlike the thin film of the present invention, the sputtered film of JP '128 forms copper wiring, not a seed layer upon which copper is required to be plated via an electrolytic copper plating process. Accordingly, the qualities of the thin film and sputtering target of JP '128 are clearly different from that of the present invention. For example, the thin film of JP '128 does not need improved wettability (coagulation resistance) to an underlying Ta/TaN diffusion barrier layer and does need to inhibit the occurrence of voids, hillocks and disconnections that often occur during electrolytic copper plating.

According to the teachings of JP '128, copper is highly susceptible to oxidation. Thus, after forming a copper alloy film of 0.7μm (7,000Å) thickness, JP '128 directs one of ordinary skill in the art to subject the thin film to heat treatment at about 500°C for purposes of providing a surface oxide film layer that provides protection against oxidation. During the heat treatment, the Al (or Si) diffuses to the surface of the film thereby forming an outer barrier layer resistant to oxidation. The Al (or Si) is dispersed and concentrated along the surface of the wiring **<u>only</u>**, and thus, the Al (and Si) are removed from the internal bulk portion of the wiring which essentially consists of pure copper. As a result of the non-uniform presence of Al (or Si) in the copper wiring, the bulk internal portion of the wiring will have high conductivity (equal to that of pure copper) and the outer layer of the wiring will resist oxidation due to the high concentration of Al (or Si).

JP '128 clearly indicates that it is the thin film (in a form provided after heat treatment) that has a resistivity of $10\mu\Omega$ cm or less. The resistivity of the sputtering target of JP '128 is not disclosed. The resistivity disclosed by JP '128 is the resistivity of a 0.7μm (7,000Å) thick layer of copper alloy that has been subject to treatment which provides a center of pure copper about which an oxidation barrier layer of Al or Si extends. Accordingly, Applicants respectfully submit that JP '128 fails to disclose a sputtering target having a resistivity of at least 2.2 $\mu\Omega$ cm (as required by claims 3 and 28 of the present application). Reconsideration of at least this aspect of the rejection stated in the Office Action is requested for this reason.

Further, the copper alloy sputtering target of the present invention does not simply provide high conductivity, it also possesses resistance of $2.2\mu\Omega$ cm or greater as well as a ratio I(111)/I(200) of an X-ray diffraction peak intensity I(111) of a (111) face and an X-ray diffraction peak intensity I(200) of a (200) face of 2.2 or more in the sputtering face, and a

variation in I(111)/I(200) in the sputtering face of respectively within ±30%. (See claims 3, 7 and 28 of the present application.) Consequently, the present invention makes it possible to effectively inhibit the generation of voids, hillocks and disconnections upon forming a thin film of about 500Å (0.05μm) thickness on which copper is plated via electrolytic copper plating techniques. These limitations are clearly not disclosed to one of ordinary skill in the art by JP '128. In fact, JP '128 provides no relevant teaching to overcome problems with respect to forming seed layers of 500Å (0.05μm) thickness much less a solution to problems of voids, hillocks and disconnections.

Still further, the technology of JP '128 is not merely different in terms of "intended use" in comparison to the present invention, but also completely lacks a disclosure of, or importance of, the X-ray diffraction intensity I(111)/I(200) being 2.2 or greater.

In the Office Action, the secondary reference Takahashi et al. is relied upon for a disclosure concerning X-ray diffraction peak intensity ratio. However, this teaching is with respect to a high purity copper sputtering target (99.999% Cu), and not to a copper alloy sputtering target. Applicants respectfully submit that the Examiner has erred in making this combination. One of ordinary skill in the art at the time the present invention was made would and must look to the entire disclosure provided by a secondary reference, such as Takahashi et al., and would not randomly pick and choose limitations from unrelated references. Here, the additive element selected for a copper alloy has a great impact on what the X-ray diffraction peak intensity I(111) of a (111) face and an X-ray diffraction peak intensity I(200) of a (200) face should be to provide the seed layer of a quality required by the claims of the present application. As an example, see the Examples in the present application with respect to Cu-Sn

and Cu-Ti alloys which have significantly different ratios than that of the copper-aluminum alloy.

There can be no mistake that the teachings of Takahashi et al. are limited to a "high purity copper sputtering target. For example, see the title, abstract and column 1, line 5, of the Takahashi et al. patent. Also, see column 2, lines 66-67, which states "The high purity copper sputtering target of this invention has an impurity content reduced to a minimum" and column 3, lines 48-49, which states "The overall copper purity, excluding the gaseous ingredients, should be at least 99.999%."

Also, there can be no mistake that Takahashi et al. provides a teaching to one of ordinary skill in the art that aluminum is considered an impurity and that the high purity copper sputtering target should contain no more than 1ppm of Al. (For instance, see the abstract of the Takahashi et al. patent.) Also see column 3, lines 23-35, which states:

> "... other impurities must also be minimized. Generally, electric resistance is a function of the impurity level and the smaller the impurity content the lower the electric resistance. Thus, in order to lower the electric resistance, a higher purity is desirable. When the actual cost of producing a sputtering target and other considerations are taken into account, it would be of great practical value to control the impurity level so that the resulting thin film shows an electric resistance **<u>below 2.0μΩ·cm</u>**.
>
> Thus not only the heavy metal elements but also such light metal elements as **<u>Al</u>**, Ca, Mg must be reduced in proportions, to 1ppm or less, preferably **<u>0.1ppm or less</u>**, each."

Thus, it is clear that one of ordinary skill in the art would view the teachings of Takahashi et al. as teaching away from the copper-aluminum alloy of the present invention and as being opposite to that taught by JP '128. In Takahashi et al., aluminum is clearly an impurity which must be reduced such that its content is no more than 0.1ppm. In addition, opposite to the claims of the present invention, Takahashi et al. teaches that electric resistance must be below 2.0μΩ·cm (and not at least 2.2μΩ·cm as required by claims 3 and 28 of the present application).

Accordingly, Applicants respectfully submit that it would not be obvious to one of ordinary skill in the art to combine the teachings of references which, when viewed as a whole, provide such opposite and contrary teachings.

Turning more specifically to the X-ray diffraction ratio limitation required by the claims of the present application, it is directed to the ratio for a copper-aluminum alloy sputtering target, not a sputtering target made of pure copper (99.999% copper). To explain this point in greater detail, the value of the X-ray diffraction peak intensity I(111)/I(200) ratio to achieve the purpose of the present invention relative to the formation of seed layers, must be selected based on the additive element of the copper alloy, and not based on a ratio for pure copper. In other words, one of ordinary skill in the art at the time the invention was made would not know what this value should equal based merely on the teachings of the pure copper sputtering target of the Takahashi et al. patent. For example, the present invention discloses additive elements of Al, Sn and Ti. With respect to the use of additive elements of Sn and Ti, the value of the I(111)/I(200) ratio required by the present invention is 2.2 **or less**. The selection of the I(111)/I(200) ratio required by the present invention for the Al additive element is completely opposite to that required for Sn and Ti.

More specifically, in the case of adding Al in the sputtering target of the present invention, the X-ray diffraction peak intensity I(111)/I(200) ratio is not derived from the Cu element of the alloy. Rather, it is necessary to select the desired value of the I(111)/I(200) ratio based on the type and amount of additive element. Thus, one of ordinary skill in the art at the time of the invention would not merely pick and choose a value disclosed by Takahashi et al. for a pure copper sputtering target for a copper alloy sputtering target. Thus, Takahashi et al. do not obviate a value for a copper-aluminum alloy, particularly to a copper-aluminum sputtering target

for forming ultra-thin film seed layers that prevent voids, hillocks and disconnections during electrolytic copper plating.

Accordingly, Applicants respectfully request fair reconsideration. One of ordinary skill in the art would not combine the opposite teachings of the cited references (JP '128 with Takahashi et al.) and would not be able to arrive at the present invention merely based on random picking and choosing of values and compositions from these references. The sputtering targets of the prior art do not disclose the formation of seed layers and the problems with providing ultra thinness yet being able to inhibit voids, hillocks and disconnections that frequently occur during electrolytic plating to seed layers. The **extremely formidable challenge** overcome by the present inventors is simply not fairly overcome or even addressed by the cited references leaving one of ordinary skill in the art without sufficient teaching to meet the challenge.

Accordingly, Applicants respectfully submit that claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 of the present application are patentable and non-obvious relative to JP '128 in view of the Takahashi et al. patent. Applicants respectfully request reconsideration and removal of the rejection.

Conclusion

In view of the above amendments and remarks, Applicants respectfully submit that the rejection has been overcome and that the present application is in condition for allowance. Thus, a favorable action on the merits is therefore requested.

Please charge any deficiency or credit any overpayment for entering this Amendment to our deposit account no. 08-3040.

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